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This report summarizes a conference held in Carmel, CA in January, 1990. The conference brought together investigators who use a variety of techniques designed to visualize the activity on the structure of the brain in awake behaving subjects. At issue was the manor in which the effects using these design techniques can be integrated so as to yield a more comprehensive view of the neurological basis of cognition.

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TOWARDS AN INTEGRATION OF THE NON-INVASIVE METHODOLOGIES OF COGNITIVE NEUROSCIENCE: THE ELEVENTH CARMEL WORKSHOP

FINAL REPORT

Submitted by

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TOWARDS AN INTEGRATION OF THE NON-INVASIVE METHODOLOGIES OF COGNITIVE NEUROSCIENCE: THE ELEVENTH CARMEL WORKSHOP

We present here a report on a conference held, on January 3-8, 1990 in Carmel, Ca. with the sponsorship of the Air Force Office of Scientific Research, Biomagnetic Technologies, Inc., John D. & Catherine T. MacArthur Foundation, James S. McDonnell Foundation, National Aeronautics & Space Administration, and the National Science Foundation. The goals of the meeting as described in the proposals submitted to the various sponsors were as follows:

> The past decade has seen a burgeoning of techniques serving Cognitive Neuroscience. There are novel radiological means for visualizing intracranial process and structure and there are novel means for recording extracranially the manifestation of information processing activities. Much of this work has been reviewed in a report published in 1989 by the National Research Council entitled: Brain and Cognition: Some New Technologies, edited by D. Druckman and John Lacey. It is evident that these two classes of techniques are complementary in the sense that the radiological approaches have impressive spatial resolution but rather poor temporal resolution while the recording approaches achieve temporal resolution in the millisecond range while their spatial resolution, with the exception of the MEG, tends to be rather poor. The issue before the conference we propose is the extent to which these approaches have been or can be integrated.
>
> Such an integration is unlikely to be limited to concurrent recording of data from a subject by multiple means. Technological and theoretical reasons dictate to each technique its own brand of experimental paradigms. Therefore, the conditions of recording which are optimal for one approach often conflict with the demands which others impose on the experiment. A necessary condition for the integration is thorough mutual understanding of the paradigmatic constraints that shape the work in each of the domains. From that understanding there may emerge a synthesis that will take the form of yet another research paradigm which will capitalize on the strength of the component techniques. This note outlines a workshop designed to help initiate such an integration. I write to inquire if your agency would consider a proposal for the support of such a conference to be conducted as the eleventh of the Carmel Conferences, a series that has been organized by the Cognitive Psychophysiology Laboratory at the University of Illinois.
>
> The conference will bring together both senior and junior investigators who represent each of the four main techniques we shall review. The two radiological approaches will be PET and MRI and the two recording approaches will be ERP and MEG. We plan to include a number of investigators who have actual experience with the use of more than one of the techniques. In addition we shall invite a group of cognitive psychologists with an interest in Cognitive Neuroscience. The number of attendees

will range from 25 to 45. The general format of the conference will follow the pattern established in the previous 10 Carmel Conferences.

It is with considerable pleasure that we report that these goals were achieved. As will be describe below, the conference was held as scheduled. With very few exceptions the participants we invited were available for the entire conference. The feedback we received from all participants was very positive.

The conference program, as well as the list of participants, are appended. Ten of the participants were invited Tutorialists who were responsible for the plenary lectures delivered during the first two days of the meeting. The various sponsoring organizations were represented by 12 individuals. The large majority of these representatives participated actively in the conference and in the panel discussions. The rest of those attending were university-based scientists. It is important to note that the conference budget provided only partial coverage for this last category of participants. The fact that most of those to whom we offered participation in the meeting accepted these terms and came to Carmel attests to the attractiveness and timeliness of the program. (Of course, that we met in Carmel may also have contributed to the meeting's attractions).

The focus of the conference can perhaps be best judged from the enclosed "Charge to the Panels." During the third and fourth day of the meeting the participants were assigned to four panels. Each panel was so "charged" such that between them the Panels were asked to address the main issues that lead us to convene the workshop. As the conference focused on the integration of the non-invasive techniques for functional, and structural, brain imaging we asked the first two panels to consider the technical issues which arise in the definition and specification of active brain loci and to conduct a comparative evaluation of the radiological, magnetic and electric procedures. The other two panels examined the interface between Cognitive Science and Neuroscience. It is to the elucidation of the interactions at that interface that the various methods we are considering are dedicated. One panel looked at the interface from the perspective of the Neurosciences and the other panel started with the view points of the Cognitive Sciences.

While we did not conduct a formal debriefing of the participants the general atmosphere, the active discussions, the numerous cross disciplinary interactions at the workshop and the remarks of many participants indicate that the workshop was a success. It was quite clear as the meeting progresses that the diversity of techniques used, each deriving from a very different scientific background, masks a general uniformity in the paradigms we all use. We were able to identify the relative blind spots of various techniques and to develop ideas as to how these can be circumvented.

It is, of course, terribly frustrating that there are inevitable tradeoffs in choosing each of the novel procedures now available for non-invasive observation of the brain. The power of a technique is on some dimensions is traded off for weaknesses in other dimensions. For

example, the very fine spatial resolution of the radiologic techniques is traded off for their very poor temporal resolution. Similarly, ERPs and MEGs who offer millisecond resolutions are very deficient in their ability to spatially resolve the origins of the potentials.

One of the most important aspects of the meeting is that it forced us to examine these trade offs in detail and to get a better perception of the particular strengths and weaknesses of the various techniques and as a consequence on the research domains to which each technique can make an important contribution. It became equally clear that the approaches are complimentary and that joint collaboration is possible and desirable.

However, the collaboration must take into account the specific attributes of the approaches. Thus, for example, it would make a lot of sense to use one of the radiologic approaches to identify the structures that are active during the activation of some information processing sub-system. However, once the structural information is identified it would make considerable sense to examine its activity by traditional psychophysiological means which allow processing to take place in real time, on a millisecond time scale, rather than integrated over many seconds.

One issue to which considerable attention was devoted in the conference was the degree to which recently proposed approaches to dipole localization, using the scalp recorded EEG are valid. The Scherg algorithm received the most critical analysis. Though, some attention was also given to the approach developed by Bio-logic Systems Corporation. Opinions were quite strongly divided on the issue. Proponents of the approach felt that it is in fact possible, in the appropriate circumstances, to identify active structures using the Scherg approach. Indeed, some of the published claims imply that dipole localization may rival radiologic, and neuromagnetic, approaches. Others found these claims a bit strong. The opposition ranged from claims that as implemented at present the dipole localization programs are more an art than a science to analyses of the approach that sought to invalidate it on mathematical and logical grounds. It is probably fair to say that, not surprisingly, no one who came in with strongly held views about the matter was lead to a change in view. The more neutral observers seem to believe that the proof of the approach would be in its successes. It would, of course, be of considerable value to compare the structural information provided by PET scans with the information provided by dipole localization algorithms.

One of the striking conclusions from the body of material we were presented is that there appears to be now confluence of data concerning the P300 components which promise to converge to a useful synthesis. The emergence of a body of data regarding the P300 was not anticipated in planning the meeting. Yet, it was clear that the following bodies of data converge. There is a rich source of converging information from intracranial recordings, from lesion studies, from neuromagnetic and from animal studies that involve at least to a degree the P300 with hippocampal activity. At the same time, there is much evidence from several laboratories that the amplitude of P300 is strongly related to the subsequent recall

of the eliciting stimuli. Finally, there is much interesting work in the study of memory, especially in amnesic patients, that relates hippocampal damage to memory deficits in a manner consistent with interpretations of the relation between P300 and memory. This has lead several of the participants to suggest that a useful topic for the next Carmel meeting could be an attempt to bring together a wide array of neuroscientists, and cognitive neuroscientist, who focus on either the hippocampal formation, memory, or P300. A proposal, calling for a meeting in January of 1992, is in preparation.

Eleventh Annual Carmel Conference

Towards An Integration of the Non-Invasive Methodologies of Cognitive Neuroscience

January 3-8, 1990

Agenda

Note: Unless otherwise indicated, all sessions will be held in the Carmel Conference Room.

Wednesday, January 3

Afternoon

4:00 - 6:00	**Registrational Reception** - The Garden Room
8:00 - 9:30	**Opening Session** - Emanuel Donchin, University of Illinois, Urbana-Champaign *"Cognitive Neuroscience - The Vessels are New, But How About the Wine? The Implications of Novel Technologies for Cognitive Neuroscience."*
10:00	Conviviality - The Executive Suite

Thursday, January 4

8:00am	Continental Breakfast

Morning Session:

9:00 - 10:00	David LaBerge, University of California, Irvine *"Why Should Cognitive Science Bother with the Brain?"* This lecture will focus on those aspects of theory and observation in cognitive science that may best benefit from the progress in cognitive neuroscience.
10:00 - 11:00	Mike Gazzaniga, Dartmouth University *"Observations on the Damaged Brain: The Oldest Profession in Cognitive Neuroscience."* The utilities and dangers of inferences from brain lesions, and how this enterprise has been affected by contemporary neuroscience.
11:00 - 12:00	Michael Coles, University of Illinois, Urbana-Champaign *"Psychophysiological Measures and the Study of Cognition."* An overview of the paradigms used in psychophysiology. Both a historical introduction to the enterprise and some illustrations of the state of the art.
12:30	Lunch served in the Poseidon Room

Afternoon Session

2:00 - 3:00 Steve Hillyard, University of California, San Diego
"The First 300 Milliseconds: Can the ERP Help Us Visualize Human Information Processing Immediately Following the Stimulus?" A review of how ERPs illuminate the pre-attentive and pre-verbal phases of human information processing.

3:00 - 4:00 Herbert Vaughan, Albert Einstein College of Medicine
"Beyond the Superficial I: Inferring the Sources of ERP Components From the Distribution of Electrical Activity on the Scalp." An introduction, and a survey, to the state of the art in source localizations inferred from EEG recordings.

4:00 - 5:00 Lloyd Kaufman, New York University
"Beyond the Superficial II: The Use of Magnetoencephalography for Localizing the Sources of Event-Related Activity." An introduction and a survey of the state of the art in source localization using MEG.

Evening Session

9:00 - 11:00 **Poster Session.** Traditionally this evening has served, in the Carmel meeting, as an opportunity for participants to present their latest data in a rather informal setting. The Garden Room.

Friday, January 5

8:00am Continental Breakfast

Morning Session:

9:00 - 10:00 Gregory McCarthy, Veterans Administration Hospital, New Haven
"Beyond the Superficial III: Intracranial Observations of Event-Related Brain Activity."

10:00 - 11:00 Marcus Raichle, Washington University, St. Louis
"Observing the Active Brain I: An Introduction to the Methods and Uses of Positron Emission Tomography."

11:00 - 12:00 James W. Prichard, Yale University
"Observing the Active Brain II: Cerebral Metabolic Studies by Magnetic Resonance Spectroscopy."

12:00 - 1:00 Michael Posner, University of Oregon
"The Proof of the Pudding? Integrating Methods in the Study of Lexical Access and Attention."

1:30 Picnic Lunch at Point Lobos (weather permitting)

Afternoon Session

At this point the meeting breaks into four panels, each of which is given a specific charge. The panels meet for the remainder of Friday as well as for the entire day Saturday, January 6, 1990. The panels are arranged so that the different orientations represented in the meeting participate in each of the panels.

Saturday, January 6

The entire day is devoted to the meetings of the panels. Meeting times will be scheduled by the panel chairmen.

8:30pm Conference Banquet - Fresh Cream Restaurant, Monterey

Sunday, January 7

8:00am Continental Breakfast

Morning Session

9:00 - 12:00 Report of **Panel I: The Identification of Intracranial Sources**

12:30 Lunch served in the Spy Glass Restaurant

Afternoon Session

2:00 - 5:00 Report of **Panel II: The Strengths and Weaknesses of the Different Technique**

Monday, January 8

Note the shift in the day's program to help those leaving after the last session.

7:00am Continental Breakfast

Morning Session

8:00 - 11:00 Report of **Panel III: The Contribution of Cognitive Science to Neuroscience**

11:30 Lunch, The Poseidon Room

Afternoon Session

1:00 - 4:00	Report of **Panel IV: The Contribution of Neuroscience to Cognitive Science**
4:15	Adjournment

Eleventh Annual Carmel Conference

Towards An Integration of the Non-Invasive Methodologies of Cognitive Neuroscience

January 3-8, 1990

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